DOCUMENT RESUME

ED 361 216 SE 053 649

AUTHOR	Baker, D.; And Others
TITLE	Letting Students Speak: Triangulation of Qualitative and Quantitative Assessments of Attitude Toward Science.
PUB DATE	Apr 92
NOTE	54p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, CA, April 1992). For related documents, see SE 053 650 and SE 053 653.
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Classroom Environment; Classroom Research; Elementary Secondary Education; Group Instruction; *Science Instruction; *Sex Differences; *Student Attitudes; Student Centered Curriculum; Teaching Methods
IDENTIFIERS	*Science Attitudes; Sentence Completion Test

ABSTRACT

Critics have concluded that paper-and-pencil science attitude measures are so flawed that the concept of science attitude should be rethought and new instruments and approaches to measuring science attitude should be devised. This study utilized student interviews to investigate student science attitudes (n=113 from grades 2, 5, 8, and 11) and written instruments for science attitude and classroom structure (n=1,084). Results suggest that there are few gender differences in attitude across the sample. However, interactions between classroom structure and gender suggest females are more likely to prefer teacher-centered classrooms. Second and fifth graders like science somewhat more that older students. Eighth graders had the most negative attitude of all students. Students preferred group activities and very open-ended, inquiry lessons. (Contains 33 references.) (PR)

Letting students speak: Triangulation of qualitative and quantitative assessments of attitude toward science

Baker, D., Piburn, M.D., Leary, R., Moffat, N., Sidlik, L., Trammel, R. & Wallin, M.

College of Education
Arizona State University
Tempe, AZ 85287

Presented at the annual meeting of the American Educational Research Association, San Francisco, CA, April 1992.

Letting students speak: Triangulation of qualitative and quantitative assessments of attitude toward science

Introduction

A substantial body of research into the phenomenon of attitude toward science has revealed several disturbing trends with serious implications in terms of the likelihood that students will continue their studies of science and enter into one of the scientific professions. Among these are both grade level and gender differences, with attitude declining as grade level increases, and a greater preference for science on the part of boys than of girls.

The pattern of those results also indicates that they might be influenced by differences in curriculum and classroom structure across the grades and as perceived by boys and girls. Thus, a comprehensive explanation of observed trends in attitude toward science would of necessity take into consideration those variables and the probability of interactions between them.

Finally, there is a literature on the topic of social role expectation and self-efficacy that suggests that positive achievement and attitudes toward science might not in themselves be sufficient pre-conditions for continued course-taking and choice of a scientific career.

One difficulty is that the literature on attitude toward science contains a well documented muddle of weak or inconsistent results that is linked to flaws in the construction of the measures. For instance, many lack theoretical constructs, scale items and scale constructs are mismatched, or scales are treated as uni- dimensional despite the fact that they have items tapping several components of attitude (Gardner, 1975). Scale dimensionality is compromised because sex and grade level responses are confounded (Rennie & Parker, 1987). Mumby (1983) suggests that "we face a problem of conceptual validity, one that demands some form of strict and disciplined attention given to just what the items themselves are saying" (p. 141).

These and other concerns have lead researchers to examine the way that attitude is measured, with particular attention to the development of assessment instruments. The strongest critics have concluded that paper and pencil measures have so many flaws that we should rethink the concept of attitude toward science and devise new instruments and approaches to measuring attitude (Mumby, 1983; Rennie & Parker, 1987). Levin, Sabar and Libman (1991) go so far as to suggest using separate samples of males and females in attitude research.

Given all of the problems associated with measuring attitude, we have approached the problem from a different perspective. We initiated our inquiry through a series of interviews with students, probing for factors that appeared to influence their attitude. Those interviews suggested substantial grade-level effects on attitude toward science, but little in the way of differences between the sexes (Baker, Niederhauser and Piburn, 1989). Since this went against the traditional wisdom (Levin, Sabar and Libman, 1991), an attempt was made to identify new techniques for further exploration of factors influencing attitude.

One which seemed particularly promising was the use of projective techniques, including cross-sex probes, sentence-completion tests and written assessments of the perceived attitudes of others. Dramatically different results with regard to self-esteem had been observed for boys and girls under these conditions by Robinson-Awana, Kehle and Jenson (1986). We chose to rely heavily on projective tests because of the assumptions which underly this approach. These are that (1) projective techniques enable students to project feelings, motives, conflicts and needs onto another which they would normally consciously or unconsciously censor (Bellak, 1975) and (2) "the way in which the individual perceives and interprets the test material will reflect fundamental aspects of his or her psychological functioning" (Anastasi, 1982, p. 564). A commonly held assumption underlying the use of projective techniques is that children attribute socially undesirable affect to ambiguous characters that they ordinarily do not to themselves (Brody and Carter, 1982).

While we have included in this study written assessments of classroom structure and of attitude toward science, our heaviest reliance remains upon an interpretation of what students tell us. The two modes that we have used to gather this information are sentence-completion and clinical interview. We are mindful, however, of the false dichotomy often suggested between quantitative and qualitative studies, and particularly the suggestion that qualitative analysis is of necessity not theoretical. We prefer to believe that the views of attitude derived from a variety of research modalities are complementary, and can only be unified by theory.

Background

The 1976-77, 1981-82, and 1985-86 National Assessments of Educational Progress documented a decline, from earlier to later grades, in attitude toward science (Ward, 1979; Hueftle, Rakow & Welch, 1983; Mullis & Jenkins, 1988). Although there have also been decreases in attitude toward science since 1977, they are not as large as the continuing differences across the grade levels.

Johnson and Johnson (1975) described the classroom as a "social milieu in which there are a variety of possible forms of social interdependence that strongly affect its members both in terms of what is learned and how learning occurs" (pg. 104). For example, peer group friendships within the class have an impact upon students' self-concepts, attitude toward school, and academic performance. In addition, student-teacher interaction is often conducted within the context of student-peer groups (Johnson, 1970), and responses to a teacher's directive are influenced by the feelings, attitudes, and relationships shared within their student-peer group. Schmuck and Schmuck (1975) have defined this "property of groupness" as a collection of interacting persons with some degree of reciprocal influence over each other.

Variables in classroom structure are powerful in determining the attitudes of students. Okebukola (1986) found that using cooperative methods of instruction with secondary science students in a laboratory setting was potent way of assisting students in developing favorable attitudes towards science. In particular, he found that females in a cooperative setting had a positive attitude toward laboratory work. Foster (1985) found that fifth and sixth grade students of both genders were more self-motivated in a cooperative learning setting. In science, Lazorowitz (1988) also found that using small, cooperative investigative groups in secondary biology class resulted in higher pupil on-task behavior, which was considered a sign of satisfaction.

It was the opinion of Talton and Simpson (1986) that the variable of classroom climate predicted the greatest amount of variance in attitude toward science in all grades. Simpson and Oliver (1990) found that across grades six to ten, class climate, other students, and friends were significant predictors of a student's attitude toward science. Results from the National Assessment of Educational Progress (Mullis and Jenkins, 1988) hint two climate variables might be particularly important. These are the degree of competitiveness and the division of control between students and teacher. It appeared that girls would prefer more student centered and cooperative classrooms, and boys more competitive and teacher centered classrooms.

Only 7% of today's high school students are choosing science and mathematics as majors when they start college (Tomlinson-Keasey, Halpern and Lundsford; 1991), and few of these are likely to be female (Hill, Pettus & Hedin, 1990). Low female enrollment in high school science classes is well known (Dearman & Plisko, 1981), fewer females than males are majoring in college science (Butler & Marzone, 1980) and only 13% of employed scientists and engineers are women (National Science Foundation, 1986).

There are conflicting opinions about gender differences in attitude toward science. While it is often reported that boys have better attitudes toward science (Fleming & Malone, 1983) the meta-analysis conducted by Steinkamp and Maehr (1983) lead them to conclude that girls do not necessarily like science less than boys and in some cases, biology and chemistry, like it more. Baker (1990) found that although girls had more negative attitudes toward science than boys, the differences had more to do with the way science was taught than with science itself. Schibeci (1989) found that gender was related to attitude in only one of the two schools in his study.

Even the most gifted female students, those who win Westinghouse Awards, are less likely than their male counterparts to plan to major in a science or a technical field in college (Campbell, 1991). Differences in academic competence, as measured by achievement, are too small to account for the size of the gender difference in male and female participation in science. Maple and Stage (1991) found that parental influence, attitudes, locus of control, number of mathematics and science courses taken, and future course taking plans, examined together in a regression analysis, accounted for only 10.9% of the variance in the selection of college major by white females.

While measured ability does not appear to contribute significantly to the range of occupations students consider as viable alternatives, self-efficacy or self-perceptions of ability are predictive of occupational choice (Betz & Hackett, 1981; Hacket & Betz, 1981). Betz and Hackett (1983) examined gender differences, math self-efficacy, and math/science college major choice. They discovered gender differences in math self-efficacy, and that these differences predicted gender differences in the math-relatedness of college majors. In a later study Hackett (1985) found that gender does have an influence on whether a student chooses to take math in high school, which in turn influences math achievement and math self-efficacy. Furthermore, the immediate predictor of choice in science or math related college majors is math self-efficacy.

Whether stated or tacit, science is still a stereotypically male field, and this stereotype is projected from the earliest years of school. Sex-typed experiences in childhood can limit exposures to information that may be necessary for the development of strong perceptions of efficacy in many occupational areas and unduly restrict the types of occupational alternatives considered by both males and females (Hackett & Betz, 1981). Therefore, the more an activity or an occupation is perceived as stereotypically male or female, the more likely it is that gender differences in self-efficacy will appear (Hackett & Betz, 1989), and the less likely that one will consider entering a nontraditional career field, even with strong interest in that area or with the necessary skills and attributes to succeed.

Thus, interest and competence in science are not enough to guarantee that a student will continue to take science courses or choose it as a career. The critical next step is the translation of self-concepts and personal constructs into operational terms. The necessary conditions for continued aspiration toward a science career appear to be described by Super's (1963, 1983) Developmental Model of Career Awareness. The major premises of Super's model are that (1) identification with an adult may result in a similar career choice, (2) experience in a role may lead to a chance in vocational role-specific self-concept and (3) awareness that one has attributes said to be important to a career may lead to investigation of the career and a decision that the career may be an appropriate choice.

Methodology

Subjects

This investigation was conducted in a unified school system serving approximately 20,000 students. The district contains five high schools, five middle schools and fifteen elementary schools. Students were sampled from two of the high schools, three middle schools and three elementary schools. This community is suburban and predominantly white, middle and upper middle class, with less than 10% minorities overall. However, two schools which were sampled documented minority populations of 33% each.

Initially, a Measure of Classroom Structure was administered to a group of 1084 students in a sample of 40 classrooms distributed evenly across the second, fifth, eighth and eleventh grades. This instrument, which is under development, was used to identify classrooms to be investigated during later phases of the research.

Based upon scores on the classroom structure instrument, four classrooms at each grade level were chosen for further study. A measure of Individual Versus Group Attitudes Toward Science was administered to all 408 students in those classrooms.

In addition, approximately ten students, half boys and half girls, were chosen randomly from each classroom for further study. A total of 113 students were asked to complete a Sentence Completion Test and to be interviewed. Interviews, which required between 30 and 45 minutes to complete, were transcribed for further analysis.

Analytic Methods

A mixture of qualitative and quantitative procedures were used for the analysis of these data. A factor analysis was conducted on the Measure of Classroom Structure, and mean factor scores used to identify classrooms for further study. Factor scores on the Individual Versus Group Attitudes Toward Science were used in a three-way Analysis of Variance to examine attitudes across grade, sex, and classroom structure. Responses to the Sentence Completion Test were categorized by two members of the research team, and a series of Chi-square analyses conducted by grade, sex and classroom structure. All members of the research team read transcripts of interviews and proposed a series of hypotheses. Individuals were then assigned to read all interviews for evidence that would substantiate or refute those hypotheses. These pieces of evidence were then submitted to the larger group for decisions about whether to retain or reject the conclusion. Ultimately, it was the task of the authors to propose unifying theoretical explanations for the richness of phenomena that were revealed by the application of these disparate methodologies.

Results

Phase 1: Classroom Structure

The major structural variables that were incorporated into the initial design and hypotheses of this study were whether a classroom was cooperative or competitive and whether it was student centered or teacher centered.

Operational definitions of these variables were as follows:

Cooperative Classroom -- a learning environment in which students help each other in an interactive way to accomplish common goals.

Competitive Classroom -- a learning environment in which students are involved in individual competition.

Teacher-centered Classroom -- a learning environment in which the teacher determines and directs learning topics and activities.

Student-centered Classroom -- a learning environment in which the students are involved in initiating the learning topics and activities.

A search of classroom psychosocial environment instruments located no single instrument specialized to measure these dimensions. Therefore, appropriate constructs were extracted from the Individualized Classroom Environment Questionnaire, Learning Environment Inventory, My Class Inventory and Classroom Environment Scale (Fraser, B. and Fisher, D., 1983). A total of 123 statements (24 cooperative, 29 competitive, 40 teacher-centered and 30 student-centered) were randomly ordered and submitted to a group of forty college education students for a validity check. Based upon the degree of agreement among this group the research instrument was reduced to forty items consisting of ten from each of the four conditions.

This <u>Measure of Classroom Structure</u> was administered to 1080 students, and the results were used as the basis for a principle component analysis followed by varimax rotation. Because of the anticipated possibility of differences in factor structure across the grade levels, separate analyses were conducted on data from grades 2 and 5 and grades 8 and 11. However, no major differences between solutions for the earlier and later grades appeared and the data were pooled for subsequent analyses.

Following the prediction that four dimensions would be required to describe classroom structure, a series of factor solutions were conducted. However, the four-factor solution was extremely similar to, and appeared to offer no substantial explanatory strength beyond, the two-factor solution. Thus, the conclusion was reached that the classrooms examined could be adequately described as varying along two dimensions (Appendix A).

Naming factors is always difficult, and has been in this study. However, first factor contains items that reflect a student's opinion that s/he has a large input into matters of the classroom, including control of the decision-making process. To a much smaller extent, it might be possible to interpret this factor as suggesting a degree of cooperative and democratic classroom climate. The second factor very strongly suggests a great deal of teacher control, and perhaps a concomitant degree of competitiveness among students.

Thus, the first result of work with this instrument is the observation that students do not clearly perceive multiple dimensions to the structure of their classrooms. The most important variable from their perspective is where control lies, in their hands or those of the teacher. Despite the attempte to include classrooms in the initial sample where cooperative learning strategies were being implemented, the distinction between competition and cooperation does not appear to be salient enough for it to emerge as a separate factor in our analyses. It is possible, of course, that the instrument was simply not sensitive to this dimension, despite the care that was taken in its construction. However, it is also likely that this distinction was not as strong among the classrooms as had anticipated. Certainly it was not through the eyes of the students.

It should also be noted that these two factors are uncorrelated, and a student might see his or her classroom as high on both, low on both, or high on one and low on the other. Thus, the second result is that there are potentially four types of classrooms. In addition to those that are high on factor one and low on factor two (student-centered) or low on factor one and high on factor two (teacher-centered), there were also classes that were either high on both factors or low on both. These should be interpreted as places where, in the eyes of students, it is either true that both they and their teacher have a large say in events of the classroom or, in the second case, where no-one is in control.

Further examination of classroom structure was based upon the factor scores of students on the <u>Measure of Classroom Structure.</u> A neutral factor score indicates no strong opinion, whereas positive or negative scores suggest that students see the class as high or low on that dimension.

Analysis of Variance reveals significant main effects for grade level and sex on students' perceptions of classroom structure. Scores on Factor 1 decline in a linear fashion as grade level increases. Second graders see their classes as most student centered, and eleventh graders theirs as least student centered (Figure 1). Factor scores for the first two grades are positive, and for the last two are negative. There are small but persistent sex differences on Factor 1, with girls perceiving their classes as less student centered than do boys. Scores on Factor 2 remain relatively constant for the second, fifth and eighth grade, with girls neutral and girls seeing the class as low on the factor and thus not teacher centered. However, there is an abrupt increase in the eleventh grade for both boys and girls, indicating an opinion that their classroom is quite teacher centered (Figure 2). The data for both factors are consistent. Students in the earlier grades see their classes as more student-centered and less teacher-centered than do those in the later grades, and girls at all levels feel that their classes are less student-centered and more teacher-centered than do boys.

Phase 2: Attitude Toward Science

After analysis of scores on the Measure of Classroom Structure, a group of classrooms that were either student-centered (high on factor one and low on factor two) or teacher-centered (low on factor one and high on factor two) were chosen for further examination. Two classrooms of each type were identified at the second, fifth, eighth and eleventh grade.

Initial analysis of attitude toward science was based upon administration of a written measure, created for this study and called Individual and Group Attitudes Toward Science, to 408 students in these 16 classrooms. Coefficient alpha for this instrument was 0.57.

This measure consisted of 30 items that were designed to tap "groupness". Twelve pertained to the student's own perceptions of the science classroom (i.e. "I think science is fun"). Another 9 assessed the student's perceiption of the class's attitude toward science (i.e. "We, the students, feel that science is worthwhile"). Finally, 9 questions assessed how the individual student saw other students' attitudes about science (i.e. "Other students like science more than I do"). Responses were made by marking an "x" along a 10 centimeter line between agree and disagree.

Factor analysis revealed four factors among items on this instrument (Appendix B). The first and fourth are both interpreted as reflecting preference for science. However, the first contains a mixture of "I" and "We" items, while the fourth is predominantly composed of "I" items. The fourth factor appears to reflect individual attitude and the first is more of a projective measure of the respondent's perception of the attitude of the group. These are tentatively labeled Attitude: Self (Factor 4) and Attitude: Group (Factor 1).

The second factor contains items that mention work, pressure, difficulty, and preferred activities. It seems to reflect a perceived level of motivation and stress, and a need to do well in the face of pressure. A high level of agreement with this factor reflects a feeling that pressure for success exists, and perhaps provides a motivation for work. For this reason, it has tentatively been labeled Motivation: Extrinsic. The third factor contains items that reflect academic self-concept, including a subject's evaluation of performance of self versus others and a perceived evaluation by the teacher. It has tentatively been labeled Motivation: Intrinsic.

Factor scores on the Individual and Group Attitudes Toward Science measure were used in a three-way Analysis of Variance, with grade level x sex x classroom structure. There were significant grade level effects for all four factors (Table 1), and significant main effects and interactions for all variables on Factor 4.

Factor means on Factor 4, Attitude: Self, decreased from earlier to later grades (F=19.58, DF=3, p=.0001), from a high of .673 in the second grade to a low of -.396 in the eleventh grade. Means on Factor 1, Attitude: Group showed a similar decrease (F=69.62, DF=3, p=.0001), beginning with a nearly perfect .996 in the second grade, declining to a low of -.648 in the eighth grade, and rebounding slightly to a modestly negative -.102 in the eleventh grade (Figure 3).

In grades two and five, there are no differences between <u>Attitude: Self</u> (Factor 4) and <u>Attitude: Group</u> (Factor 1). However, by the eighth grade the two scores have separated, and there is a reversal of means between the eighth and eleventh grades (Figure 3). In the eighth grade, students express more positive personal attitudes (Factor 4) than they attribute to the group (Factor 1). In the eleventh grade they attribute more positive attitudes to the group (Factor 1) than they express for themselves (Factor 4).

Scores on <u>Attitude: Self</u> (Factor 4) also showed additional main effects and interactions. Students in student-centered classrooms had higher factor scores than those in teacher-centered classrooms ($F=20.81$, $DF=1$, $p=.0001$) and boys had higher scores than girls ($F=10.77$, $DF=1$, $p=.001$). There were significant interactions between grade and sex ($F=2.67$, $DF=3$, $p=.05$) and between grade and classroom structure ($F=3.80$, $DF=3$, $p=.01$). These interactions show that, as grade increases the attitude of students in teacher-centered and and student-centered classrooms decrease and become more alike (Figure 4) and the gap in attitude between boys and of girls widens, with girls' attitude decreasing more rapidly than boys' (Figure 5).

There were significant main effects for grade level on Factors 2 ($F=4.48$, $df=3$, $p=0.004$) and 3 ($F=4.71$, $df=3$, $p=.003$), with a similar pattern. Mean factor scores on <u>Motivation: Extrinsic</u> (Factor 2) began and ended negative, with a slightly positive plateau in grades five and eight (Figure 4). Means on

Motivation: Intrinsic (Factor 3) began and ended positive, with a minimum in the middle grades (Figure 6). Thus, students in second and eleventh grades felt little pressure or extrinsic motivation but were relatively secure about their own abilities. In the middle grades, increased pressure and desire for performance seems to have been coupled with a concomitant decrease in academic self concept and intrinsic motivation.

Phase 3

The Sentence Completion Test was administered to 113 students, approximately half male and half female, from the same 16 classrooms in which the written measure of attitude was given. Students were asked to complete 20 open-ended questions such as "If I told my mother that I wanted to be a scientist, she would...." or "My friends think that science is...". In contrast to objective tests where subjects are forced to choose their answers, sentence completion tests, because they are projective, give the subject the freedom to respond in an almost unlimited fashion (Anastasi, 1982: Rotter, 1964).

Two members of the research team read and categorized responses to each item. Chi-square analysis was then conducted for each question to see if there were significant differences in response frequency across sex, classroom structure and grade.

Four questions yielded a generalized picture of students' attitudes toward science. These were 20) "I think science...", 2) "My friends think science...", 5) "My mother thinks science...", and 18) "My father thinks science...". The highest frequency of positive response (83%) was on the first item. Although they themselves held almost universally positive attitudes toward science, students were evenly split on whether they thought their friends had positive (44%) or negative (43%) attitudes. More attributed positive attitudes to their fathers (45%) than to their mothers (33%). Very few thought that either their fathers (4%) or mothers (10%) had negative attitudes toward science.

These items also yielded some interesting grade-level differences. On the first (20), 90% of the negative responses were from the 8th or 11th grades (chi-square=9.4, DF=3,p=0.02). On the second (2), 8th graders gave the lowest frequency of positive responses (chi-square=21.6, DF=4, p=0.000), and 8th and 11th graders gave the highest frequency of negative responses (chi-square=13.5, DF=4, p=0.009). On the third (5), 8th graders were most likely to give a neutral response (chi-square=9.9, DF=3, p=0.20) and on the last (18), they were least likely to believe that their fathers had a positive attitude toward science (chi-square=11.1, DF=3, p=0.011). There is a greater tendency for students in Student Centered Classrooms to believe that their father would have a positive attitude (chi-square=4.7, DF=1, p=0.030),

Item (6), "I feel that my science teacher...", yielded information both about whether students liked the teacher and whether they thought s/he taught well. More liked the teacher

(39%) than thought s/he taught well (29%), and more disliked the teacher (17%) than thought s/he taught poorly (9%). Among grades, students in the 11th were most likely to like their teacher (chi-square=34, DF=3, p=0.000) and say s/he was a good teacher (chi-square=34.3, DF=3. p=0.000), while those in the 8th were most likely to dislike their teacher (chi-square=8.7, DF=3, p=0.034). Those in Teacher Centered Classrooms were more inclined to dislike their teacher (chi-square=5.8, DF=1, p.=0.016) and to rate him or her as poor (chi-square=5.5, DF=1, p=0.019).

Four items, 11) "I wish my science teacher...", 3) "If I were in charge of a science group project, I...", 7) "In science, I am afraid of...", and 8) "What I want most out of this science class is...", yielded some information about preferences. Among these were more activities (32%), hands-on projects (25%), things that are fun (17%), things that are easier (16%) and less structured (7%). Those in Student-Centered Classrooms were especially anxious that there be more activities (chi-square=5.3, DF=1, p.=0.021). Students thought that their teacher should teach better (18%) and be nicer (10%). Females in Student Centered Classrooms were particularly concerned that their teacher should be nicer (chi-square=9.5, DF=3, p=0.024). All students in Teacher Centered Classrooms thought the teacher should be easier (chi-square=6.0, DF=1, p=0.015). Half of the students were afraid of failing. What they wanted most from the class were to learn (52%), to get a good grade (17%), to do activities (10%), and to have fun (9%).

Six items probed sex differences. These were 9) "In science I think most boys...", 15) "In science I think most girls...", 19) In science, what I like most/least about boys is...", 4) "In science what I like most/least about girls is...", 10) "If I were a scientist my mother...", and 13) "If I were a scientist my father...". The frequency of positive responses to each of these was virtually identical (29-30%) as was the frequency of negative responses (32-38%). However, students in Student Centered Classrooms were much more likely to make negative comments about girls ((chi-square=12.5, DF=1, p=0.000), while those in Teacher Centered Classrooms were more likely to make positive comments (chi-square=3.9, DF=1, p=0.047). Across these items, statements that there was no difference between boys and girls occurred between 3% and 10% of the time. Girls (chi-square=5.8, df=1, p=0.06) and 5th and 11th graders (chi-square= 11.4, DF=3. p=0.01) were more likely to give this response in answer to the third item. Most students felt that both their father (61%) and mother (68%) would support their becoming a scientist. However, girls were more likely to believe that their fathers (chi-square=14.4, DF=1, p=0.000) and their mothers (chi-square =3.5, DF=1, p=0.062) would react positively than were boys.

Two statements, 12) "My feeling about science as a career is..." and 16) "I would like to learn more about science because in the future I..." revealed attitudes about careers in science. While 55% of the students responded that they needed information from science for their career, only 39% said that they would consider a career in science. Eighth graders were least likely to feel that they needed to study science in prepartion for a career (chi-square=10.1, DF=3, p=0.018). There is an unusual interaction between sex and classroom structure. Females in Teacher Centered classrooms are <u>less</u> likely to say that they will not consider a career in science whereas boys are <u>more</u> likely to say that they will not.

<u>Phase 4: Interviews</u>

Interviews were conducted by six members of the research team, two females and four males, and three faculty and three graduate students. Subjects were randomly assigned to each interviewer. Subjects were removed from their classes to separate rooms for interviews, which were tape recorded and subsequently transcribed. Interviews took approximately 30-45 minutes, and each researcher could complete one or two during a typical class period.

All interviewers followed a protocol which specified particular types of probes and their order, but also encouraged individual digressions to follow up interesting issues. All interviews began by asking the subjects to describe their science classes, and asking how they felt about them. Subjects were then asked cross-sex questions about how they (girl/boy) would feel about growing up to be a scientist, how their friends (girl/boy) would react to knowing the subject wanted to be a scientist, and what their parents (mother/father) would say about their being a scientist. Finally, subjects were asked how they would teach science, if they were the teacher, and what they would do to improve the attitude of girls and of boys.

The results of these interviews were grouped into seven categories for discussion.

Careers

One of the strongest conclusions from the interviews was that students have a narrow view of science careers, and do not know what science preparation is needed for many careers. They are attracted to high presige and lucrative careers and science is not perceived as such. Despite expressing positive attitudes toward science, students do not indicate an intention to enter a science career.

Students see both their friends and their parents as supportive of any career choice. Partricularly for girls, the association with a very significant family member or friend who encourages a scientific career is very important, and especially if that person is also female.

Self/Group Differentiation

Although it is more typical of younger students than of older ones, all students have difficulties evaluating the attitudes of others, especially those of the opposite sex. Most students report that they like science, but attribute a poorer attitude to others others (including classmates and parents) than they claim for themselves.

All students hold more stereotypes about others than about themselves. This is particularly true of gender stereotypes. For example, both boys and girls claim that girls dislike certain types of activities even while admitting that is not true for themselves, friends or relatives.

Teacher Versus Student Centered Classrooms

Pupils in classrooms that they see as student centered have a better attitude than those in classrooms seen as teacher centered. As might be expected from this result, students in teacher centered classrooms think less well of their teachers than those in student centered classrooms. Interviews reveal that students in earlier grades see their classes as more student centered, while those in later grades see them as more teacher centered.

Attitude Toward Content

It appears from the interviews that content is not as important a variable in establishing attitude as are the feelings of students about the teacher. Also, the way in which content is delivered is more important than the nature of the content itself.

All students appear to like content from both the life and physical sciences. Girls show a slight antipathy toward such activities as dissections before conducting them, but not afterward. All students prefer content which is relevant to them, and dislike content which is conceptually too difficult.

General Attitudes

Pupils in grades 8 and 11 have poorer attitudes toward science than those in grades 2 and 5. There is an inverse relationship between pressure to succeed and a sense of efficacy and academic self-concept which contributes to the decline in attitude through the grades. Students' principal anxieties in science classes involve the complexity of the content and a fear of failure.

Stereotypes

All students hold stereotypes of others, although boys are more likely to express them than are girls. Boys hold more stereotypes about girls than girls do of themselves. Asking students to take the point of view of the opposite sex does not change their answers.

Pedagogy

How science is taught is more important than what is taught. Students prefer hands-on manipulative, unstructured activities. They like to work in social groups, preferably sex segregated.

Elementary students learn about science and develop attitudes more as a result of out-of-school experiences rather than instruction in school. This is a predominantly male experience.

Conclusions

The analyses suggest that there are few gender differences in attitude across the total sample. However, there are interesting interactions between classroom structure and gender, with females more likely to prefer teacher centered classrooms and males student centered classrooms. Many of the traditional stereotypes, such as boys preferring physical and girls life sciences, were not born out.

Grade level differences also emerged. Second and fifth graders liked science somewhat more than older students. Eighth and eleventh graders were similar, but eighth graders had the most negative attitude of all students.

The discovery that there are not major sex differences in attitude toward science is surprising, and will require a serious re-examination of the differential participation by males and females in the sciences. If its origins do not lie in attitude, then they must be searched for elsewhere.

There is no evidence from interviews that girls like science any less than boys, nor that they prefer different activities. However, students are aware of cultural stereotypes. For instance, both boys and girls reported that girls do not like dissections, despite the fact that the very same subjects indicated that the girls *they* knew (including themselves, if female) *did* like such activities. Both boys and girls seem to agree that girls are more serious students and that boys fool around too much.

The origins of the observed decreases in attitude with grade level are clarified a great deal by this research. Students appear, in general, to prefer student centered cooperative classroom structures, and perceive that this becomes less and less a characteristic of school as they move upward through the grades. Most likely this is the actual case, since most of us would expect primary grade classes to be more student oriented than those in the high school. As a result, one would expect a concomitant decrease in attitude.

This accords favorably with previous research, in which students reported that they preferred group activities and very open-ended, inquiry lessons. In later grades, both of these became less frequent, and students associated this with increasing dissatisfaction with science.

Thus, it appears that classroom structure has emerged from this research as a powerful correlate of attitude toward science, and deserves further examination. In the current study, the classrooms studied were either teacher centered or student centered. However, classes were also noted which were high on both factors or low on both. It is very likely that a richer understanding of the impact of the structure variable would be gained by examining a sample of classrooms from each of the four possible quadrants: a) Both student and teacher are powerful forces, b) Teachers dominate, c) Students are in control, and d) Nobody is in control.

Finally, this research is based entirely upon the perceptions of students, and no attempt has been made to relate this to how teachers think about their classes, or to what actually occurs in those classes. The rationale for this approach is that it is the perception of students that drives their attitude, regardless of what is objectively true. However, an obvious next step is to conduct interviews with teachers and make observations of their classrooms, since the ultimate questions regard how classroom events are translated by students into memories and thus attitudes.

In the meantime, some practical suggestions have emerged for those interested in improving the attitude of their students toward science. The most powerful predictor appears to be classroom structure, with students preferring greater involvement in structuring events, rules and assessment. It should be possible, by manipulating this variable, to improve attitude without any decline in achievement.

REFERENCES

Anastasi, A. (1982). Psychological Testing. New York, NY: MacMillan.

Baker, D. (1990). Gender differences in science: Where they start and where they go. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Atlanta, GA.

Baker, D., Niederhauser, D. and Piburn, M. (1989). Attitudes and Stereotyping in Science: Trends and Transitions k-12. Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Bellak, L. (1975). The TAT, CAT, and SAT in clinical use. New York, NY: Grune and Stratton.

Betz, N.E. and Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. Journal of Counseling Psychology, 28, 399-410.

Betz, N.E. and Hackett, G. (1981). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. Journal of Vocational Behavior, 23, 329-345.

Brody, L.R. and Carter, A.S. (1982). Children's emotional attributions to self versus other: An exploration of an assumption underlying projective techniques. Journal of Consulting and Clinical Psychology, 50(5), pp. 665-671.

Campbell, J.R. (1991). The roots of gender inequities in technical areas. Journal of Research in Science Teaching, 28(3) 251-264.

Fleming, L. and Malone, M. (1983). The relationship of student characteristics and student performance in science as viewed bv meta-analysis research. Journal of Research in Science Teaching, 20(5), pp. 481-495.

Foster, G.W. (1985). Creativity in a cooperative group setting. Journal of Research in Science Teaching, 22(1), 89-98.

Gardner, P. (1975). Attitudes to science: A review. Studies in Science Education, 2, pp. 1-41.

Hackett, G. (1985). The role of mathematics self-efficacy in the choice of math-related majors of college women and men: A path analysis. Journal of Counseling Psychology, 32, 47-56.

Hacket, G. and Betz, N.E. (1981). A self-efficacy approach to the career development of women. Journal of Vocational Behavior, 18, 326-339.

Hackett, G. and Betz, N.E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. Journal of Research in Mathematics Education, 20, 261-273.

Hill, O.W., Pettus, W.C. and Hedin, B.A. (1990). Three studies affecting the attitudes of blacks and females toward the pursuit of science and science related careers. Journal of Research in Science Teaching, 27(4), 289-314.

Johnson, D.W. (1980). The social psychology of school learning. New York: Academic Press.

Johnson, D.W. and Johnson, R.T.(1975). Learning together and alone: Cooperation, competition and individualization. Englewood Cliffs: Prentice-Hall, NJ.

Lazarowitz, R., Hertz, R.L., Baird, J.H. and Bowlden, V. (1988). Academic achievement and on-task behavior of high school biology students instructed in cooperative small investigative groups. Science Education, 72(4), 475-487.

Levin, T., Sabar, N. and Libman, Z. (1991). Achievements and attitudinal patterns of boys and girls in science. Journal of Research in Science Teaching, 28(4), pp. 315-328.

Maple, S.A. and Stage, F.K. (1991). Influences on the choice of math/science major by gender and ethnicity. American Educational Research Journal, 28(1), 37-60.

Mullis, I.V.S. and Jenkins, L.B. (1988). The science report card: Trends and achievement based on the 1986 National Assessment. Princeton, NJ: Educational Testing Service.

Mumby, H. (1983). Thirty studies involving the "scientific attitude inventory": what confidence can we have in this instrument? Journal of Research in Science Teaching, 20(2), 141-162.

Okebukola, P.A. (1986). Cooperative learning and students' attitude to laboratory work. School Science and Mathematics, 86(7). 582-590.

Robinson-Awana, P., Kehle, T.J., and Jenson, W.R. (1986). But What about smart girls? Adolescent self-esteem and sex role perceptions as a function of academic achievement. Journal of Educational Psychology, 76(3), pp. 179-183.

Rotter, J.B. (1964). Word association and sentence completion methods. In H.H. Anderson and G.L. Anderson (eds.), An introduction to projective techniques. Englewood Cliffs, NJ: Prentice-Hall.

Schibeci, R.A. (1989). Home, school and peer group influences on student attitudes and achievement in science. Science Education, 73(1), 13-24.

Schmuck and Schmuck (1975). Group processes in the classroom. Dubuque: Wm. Brown.

Simpson, R.D. and Oliver, J.S. (1990). A summary of major influences on attitude toward and achievement in science among adolescent students. Science Education, 74(1), pp. 1-18.

Steinkamp, M. and Maehr, M. (1983). Affect, ability and science achievement: a quantitative synthesis of correlational research. Review of Educational Research, 53(3), pp. 369-396.

Talton, E.L. and Simpson, R.D. (1986). Relationships of attitude towards self, family and school with attitude toward science among adolescents. Science Education, 70(4), pp. 365-374.

Tomlinson-Keasey, C., Halpern, B.L. and Lundsford, L.G. (1991, August). Scientific aspirations and achievement among adolescents. Paper presented at the annual meeting of the American Psychological Association, San Francisco, CA.

Wareing, C. (1990). A survey of antecedents of attitudes toward science. Journal of Research in Science Teaching, 27(4), pp. 271-386.

Wilson, V. (1983). A meta-analysis of the relationship between science achievement and science attitude: kindergarten through college. Journal of Research in Science Teaching, 20(9), pp. 839-850.

Table 1. Individual and Group Attitudes Toward Science: Mean factor scores of subjects by grade level

		FACTOR			
		I	II	III	IV
GRADE	2	.996	- 286	.289	.673
	5	.266	.083	-.148	-.089
	8	-.648	.170	-.163	-032
	11	-.102	-.112	.182	-.396

Figure 1. Mean factor scores of males and females in grades 2, 5, 8 and 11 on Factor 1 of the <u>Classroom Structure Measure</u>.

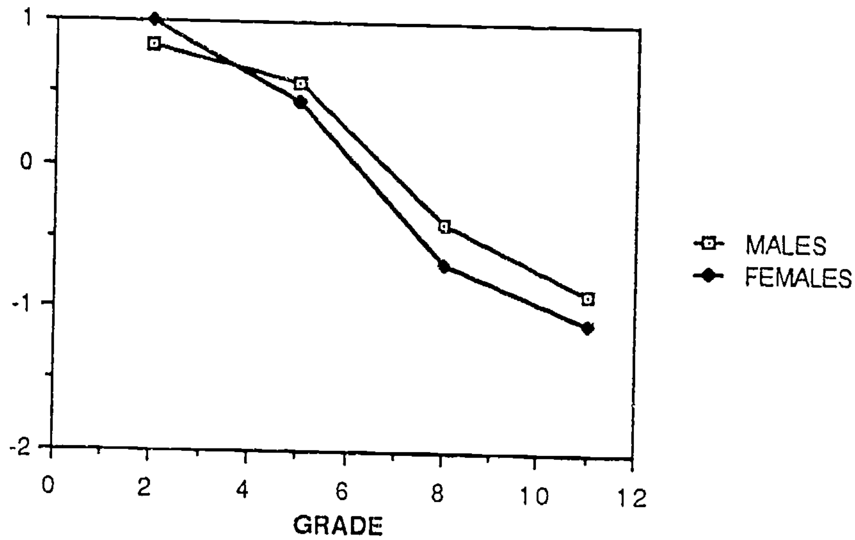

1
0
-1
-2
0
2
4
6
8
10
12
GRADE
MALES
FEMALES

Figure 2. Mean factor scores of males and females in grades 2, 5, 8, and 11 on factor 2 of the <u>Classroom Structure Measure</u>.

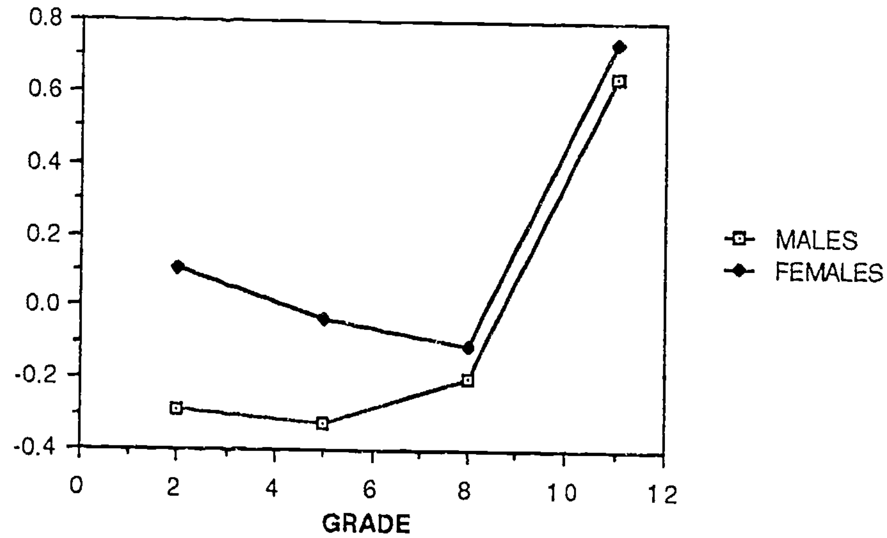

0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
0
2
4
6
8
10
12
GRADE
MALES
FEMALES

Figure 3: Mean factor scores for grades 2, 5, 8, and 11 on factors 4 (attitude: self) and 1 (attitude: group) of _Individual and Group Attitudes Toward Science_

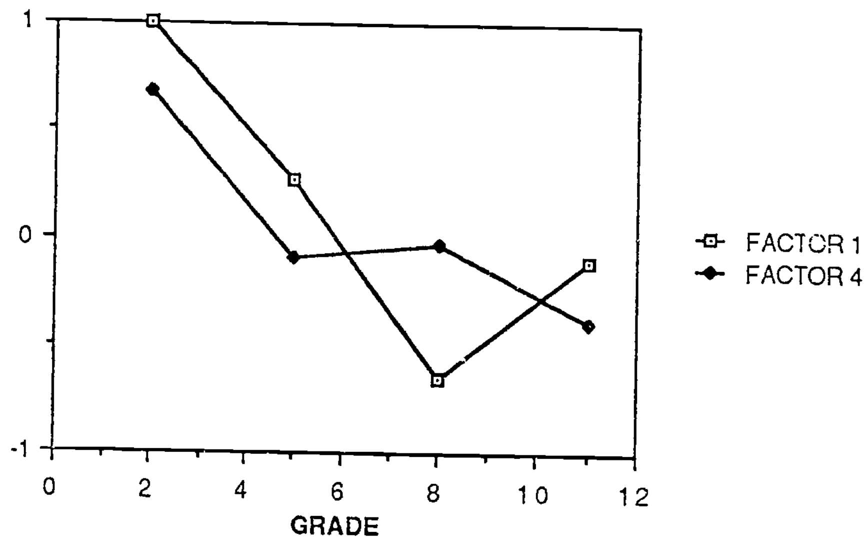

1
0
-1
0
2
4
6
8
10
12
GRADE
FACTOR 1
FACTOR 4

Figure 4: Mean factor scores of student- and teacher-centered classrooms on factor 4 (attitude: self) of Individual and Group Attitudes Toward Science

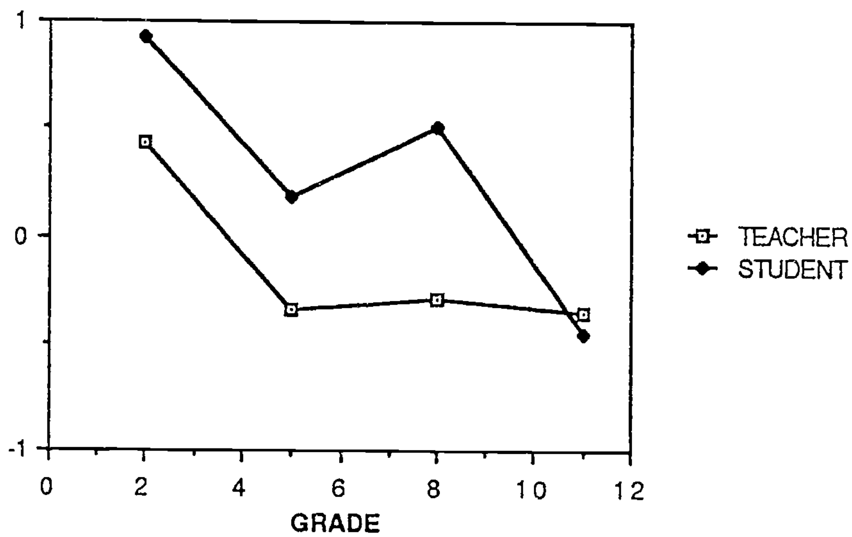

1
0
-1
0
2
4
6
8
10
12
GRADE
TEACHER
STUDENT

Figure 5: Mean factor scores of males and females on factor 4 (attitude: self) of Individual and Group Attitudes Toward Science.

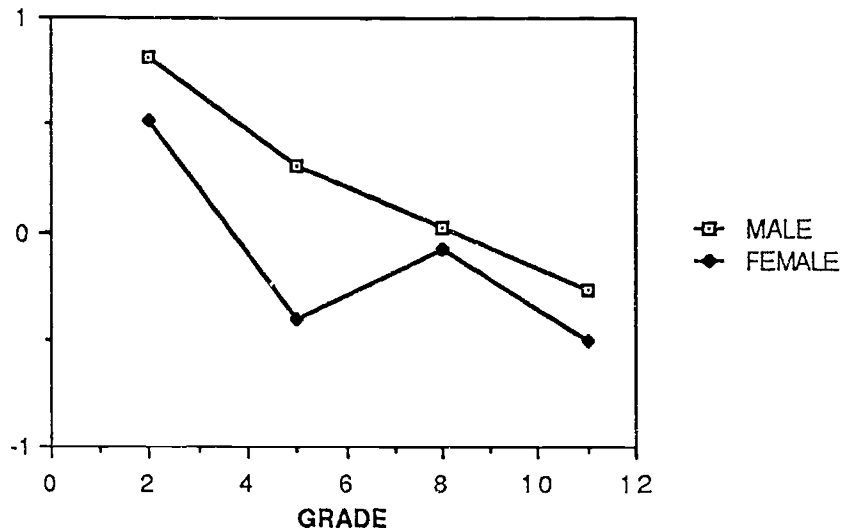
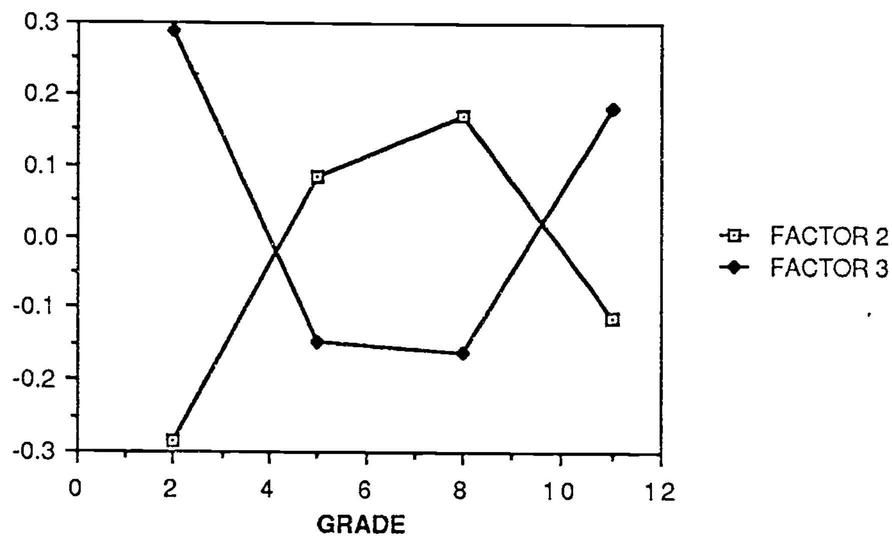

1
0
-1
0
2
4
6
8
10
12
GRADE
MALE
FEMALE

Figure 6: Mean factor scores of grades 2, 5, 8 and 11 on factors 2 (motivation: extrinsic) and 3 (motivation: intrinsic) of Individual and Group Attitudes Toward Science.


0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
2
4
6
8
10
12
GRADE
FACTOR 2
FACTOR 3

APPENDIX I.

Factor Structure of Classroom Structure Measure

		FACTOR 1	FACTOR 2
37)	Class decisions tend to be made by all the students.	.64	-.02
12)	Class decisions tend to be made by all the students.	.59	-.00
3)	Decisions affecting the class tend to be made democratically.	.42	.00
17)	Students ideas and suggestions are used during classroom discussions.	.45	-.20
33)	The teacher remains at the front of the class rather than moving about and talking with students.	-.39	.09
32)	The teacher tries to find out what each student wants to learn about.	.36	.18
28)	Each member of the class has as much influence as any other member.	.32	-.28
25)	Students are asked to follow strict rules in this class, but the students are given a chance to discuss these rules with the teacher.	.31	.17
31)	There is a great deal of conversation going on in our class, but most of it is related to projects we are working on.	.30	-.18
4)	New and different ways of teaching are not tried very often in this class.	-.28	.07
9)	The class is rather informal and few rules are imposed.	.22	.13
16)	The teacher decides which students should work together, but we get opportunities to work with people outside our group.	.24	-.02
13)	Students carry out investigations to test ideas.	.24	-.07
35)	Investigations are used to answer teachers' questions.	.25	-.09
24)	When students finish with their work, they are expected to help others.	.23	.04
15)	The teacher sets goals for our class, but each student works toward those goals at their own pace.	.22	.09
38)	Students find the answers to questions and problems from the teacher rather than from investigations.	-.17	.11
6)	Students discuss their work together.	.18	-.09
20)	In this class, students are allowed to make up their own projects.	.16	.08
1)	Students are encouraged to be considerate of other people's feelings and ideas.	.17	-.13

19)	Even though the students work on different things in class, most students want their work to be better than their friends' work.	.01	.02
2)	We all do our own work, but some students race to see who can finish first.	.00	.07
29)	The teacher decides which students should work together.	-.01	.08
7)	Even though students work at different ability levels, the grades are periodically posted which causes students to compare themselves to others.	-.10	.10
14)	It takes a long time to get to know everybody by their first name in this class.	-.05	.15
36)	The goals of this class are very general, and each student works individually to achieve those goals.	.02	-.14
5)	There is a recognized right and wrong way of going about class activities.	.01	-.17
8)	Though the objectives are many times unclear, the teacher rewards those students who individually work hard to achieve the highest grade.	.08	.28
22)	Certain people work in groups together all the time and the groups see who can do the best work.	.08	.30
11)	Because we all do our own work, the students in this class don't know each other very well.	-.08	.28
10)	There are set ways of working on things in class.	-.05	-.28
39)	Group projects performed in this class have a specific goal.	.26	-.31
40)	All students in the class do the same work at the same time.	-.04	-.35
21)	The better students are granted special privilíges.	-.08	.38
30)	The students have to guess at what the teacher wants accomplished in class, and the students are encouraged to work against each other.	-.13	.41
34)	Different students use different books, equipment and materials.	-.12	.43
18)	The teacher makes the rules and they seem to change a lot.	-.19	.43
27)	The same teaching aid (e.g. blackboard or overhead projector) is used for all students in the class.	-.03	-.48
26)	All students are expected to do the same amount of work for the lesson.	-.01	-.48

APPENDIX II.

Factor Structure of
Individual and Group Attitudes Toward Scioence

	Factor 1	2	3	4
FACTOR I				
1) Science lessons are fun for me.	.68	.29	-.06	.01
2) We see this science class class as being worthwhile.	.64	.25	-.20	.23
4) We feel that science is a waste of time.	.59	-.09	.03	-.08
6) My friends are better at science than I am.	-.68	-.24	.02	.07
7) I think other students in class like science more than I do.	.76	.10	-.06	-.03
8) We a positive attitude toward our science class.	.50	-.14	.19	-.23
9) I feel pressure to do well in science class.	.63	.13	-.19	.12
10) I get good grades in science.	.65	.22	-.08	.25
11) We respect our science teacher.	.58	-.14	-.14	-.05
FACTOR II				
13) Scientists like music as much as other people.	.01	.57	-.01	-.23
14) I don't like science lessons.	-.05	-.58	.32	.07
15) We feel pressure to do well in this science class.	.12	.71	-.17	-.00
16) Students prefer to work alone in this science class.	.03	.64	-.10	-.25
17) I like science more than other students.	.13	.50	-.16	.31
20) I like reading about science in books, magazines and newspapers.	.15	.67	-.35	-.02
26) Science is an easy subject for me.	.09	.56	-.04	.10

FACTOR III

23)	We feel that science lessons are fun.	-.03	-.01	.60	.15
24)	Other students in my science class spend more time on their science homework than I do.	-.19	-.19	.63	.13
28)	My science teacher does not know what I like about science.	-.07	-.05	.66	-.06
30)	I think other students will make better scientists than I will.	-.16	-.03	.74	.01

FACTOR IV

3)	I would like to belong to a science club.	.03	.05	.03	.38
5)	I think other students' parents encourage them to do well in science.	.17	-.04	.15	-.32
12)	We would like the opportunity to get to work with everyone in this science class before the end of the school year.	-.29	-.20	-.05	.43
18)	I am better than other students in science.	.06	.19	.17	.54
19)	Most of the other students in my science class like science.	.04	-.28	.14	.51
25)	I would like to be a scientist someday.	.17	-.18	-.17	.27